Farnell

TM8 AUTORANGING
R.F. MILLIVOLTMETER

INSTRUCTION BOOK

MP MASTER
MA23432

INSTRUCTION BOOK FOR

TM8 AUTORANGING R.F. MILLIVOLTMETER

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SCHEDULE OF EQUIPMENT

1 off Farnell TM8 r.f. millivoltmeter
1 off instruction book
1 off detachable power lead
1 off accessory wallet containing:
1 off probe to BNC adapter
1 off BNC 'T' piece
1 off x 100 multiplier (high impedance divider)
1 off spare probe tip
1 off probe earth clip

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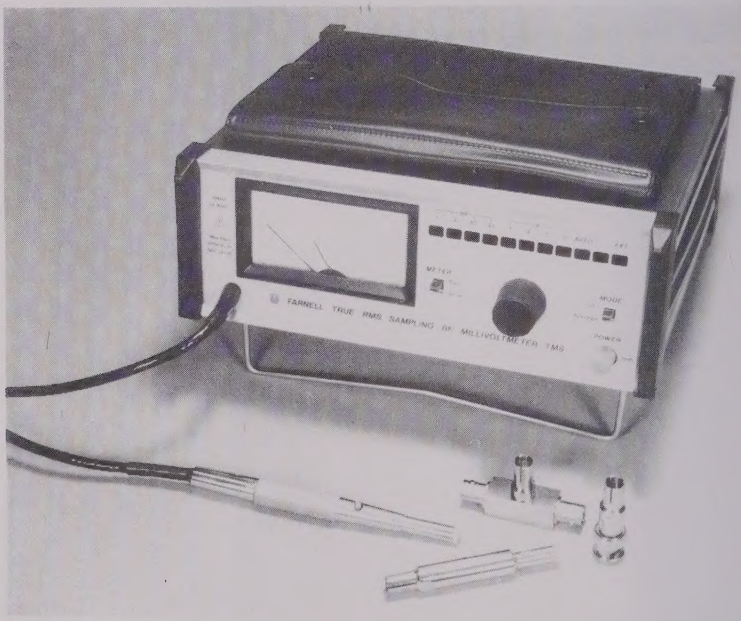


TM8 AUTORANGING R.F. MILLIVOLTMETER

INTRODUCTION

The Farnell TM8 is an autoranging, true r.m.s. millivoltmeter with a specified operating range of 10kHz to 1GHz with useful indications to 1500MHz It measures r.f. voltages from 1mV to 3V FSD in eight ranges and may be operated automatically (in the autoranging mode), manually or remotely. The maximum voltage measured can be increased to 300V r.m.s. using the 100:1 divider provided.

Measurements are true r.m.s. but average responding can also be selected with a front panel switch. The meter reads 100μV-3V and also features a corresponding dB scale from -60 to + 23dBm. A single logarithmic range is also provided and covers four decades scaled -30 to + 10dBm. Fast or slow meter response may be selected to permit the observation or removal of rapid signal amplitude changes.

Remote programming is a standard feature and the socket is located on the rear panel. An output to drive a pen recorder is also provided from this socket. The TM8 is supplied complete with probe (integral with input lead), probe to BNC adapter, 'T' connector, and a 100:1 high impedance divider.

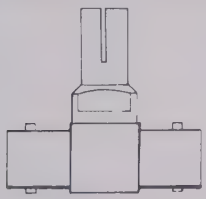
SPECIFICATION

VOLTAGE RANGES	1mV to 3V FSD in 8 ranges, true r.m.s. or average responding (selected by switch). Meter also calibrated in dB (-50 to +20dBm, 50Ω)
RANGE SELECTION	Manual: Select with range switch Auto: Select auto for autoranging Remote: Select ext. for programming
OPERATING FREQUENCY RANGE	10kHz to 1GHz
VOLTAGE ACCURACY (WITH ADAPTER AND 50Ω LOAD)	Basic accuracy: ± 1% FSD at 20°C, 100MHz Frequency accuracy: ± 1% FSD 100kHz to 200MHz or ± 4% FSD 20kHz to 500MHz or ± 10% FSD 10kHz to 1GHz Temp coefficient: ± 0.1% FSD $°C^{-1}$
LOGARITHMIC RANGE	+ 10 to -30dBm, 50Ω in a single four decade dB scale. Accuracy ± 2dBm.
MAXIMUM INPUT TO PROBE	20V r.m.s. a.c. 200V d.c.
PROBE INPUT IMPEDANCE	100kΩ in parallel with 2.5pF typical
CREST FACTOR	12dB at FSD on all ranges up to 1V 3dB at FSD on 3V range (crest factor increases inversely for readings below FS).
METER DAMPING	Front panel switch gives either *fast* or *slow* response of meter and pen recorder output.
METER READING ANALOGUE OUTPUT	Available from rear panel programme socket.FSD is 1V, buffered low impedance output.
REMOTE PROGRAMMING	Range selected by b.c.d. code, TTL levels negative logic.
READING HOLD	Momentary switch on probe holds meter reading to within 1% for at least three minutes.
OPERATING AMBIENT TEMPERATURE RANGE	0 to 40°C
POWER REQUIREMENTS	115V or 230V + 20%-25% (selected on rear panel) 48 to 440Hz 5VA approx.
EXTERNAL D.C. POWER SUPPLY INPUT	Via rear panel multiway connector ± 15V to ± 30V d.c. 200mA max.

ACCESSORIES SUPPLIED	BNC 'T' connector High impedance 100:1 divider BNC to probe adapter Spare probe tip Probe earthing clip Accessories wallet Remote programming connector Power lead Instruction book
OPTIONAL BNC ACCESSORIES	50Ω load 20dB, 50Ω pad 50Ω through line termination 75Ω through line termination
DIMENSIONS & WEIGHT (APPROX)	Height 85mm Width 220mm Depth 225mm Weight 2.15kg

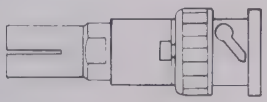
ACCESSORIES SPECIFICATION

Probe to BNC 'T' connector

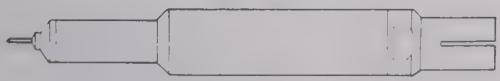


Instrument specification applies only with this adaptor and 50Ω load.

Probe to BNC adapter



High impedance 100:1 divider



Add ± 6% of reading from 1MHz to 500MHz.

Warning: When measuring high voltages at high frequencies the probe to BNC adaptor must be used, as dangerous voltages may be induced on the probe body. The probe should not be handled when making high voltage measurements.

OPERATING INSTRUCTIONS

Installation

Check that the slider switch on the rear panel is set according to the local power supply, either 230V or 115V 50Hz, adjust if necessary.

Connect a suitable power plug to the lead, observing the following code:

L	power live	- brown
N	power neutral	- blue
E	earth	- yellow/green

Switch unit on using front panel push button at left hand side of unit.

Operation

Select the appropriate position for the range switch on the front panel, depending on whether manual selection, automatic selection, single range logarithmic or external programming of range is required.

For automatic ranging, the range will be automatically selected for a meter reading within the approximate range of 20% to 105% FSD. Range annunciation is indicated by front panel LEDs. Using the meter and mode switches on the front panel select for true r.m.s. or average detection and fast or slow meter response.
In order to display large variations in signal level, a single four decade logarithmic range is provided by selecting the log position on the range switch.

Probe notes

The probe is calibrated for use in 50Ω systems using the 'T' piece provided and optional 50Ω load.

CAUTION:
Do not exceed the maximum probe input of 20V r.m.s. a.c. or 200V d.c.

A spare probe tip is provided as standard, others are available if ordered through the service department (see page 15 for address)

Meter Zeroing

Occasional resetting of the 1mV zero may be required. Select the 1mV range and terminate the probe in the 'T' piece and 50Ω load, then adjust P12 for meter zero.

N.B. P12 is located under the right hand handle nearest the back panel.

IMPEDANCE MATCHING ARRANGEMENT

When it is desired to cross check a signal generator r.f. output with the TM8 millivoltmeter it is imperative that the two are connected together with the best possible impedance match.

During the calibration of this instrument, low VSWR 50Ω components are fitted directly onto the output connector / probe and so, to obtain repeatable results, these settings must be simulated.

The connector combination shown below most nearly approaches the original calibration conditions and any deviation can be expected to produce out of specification errors.

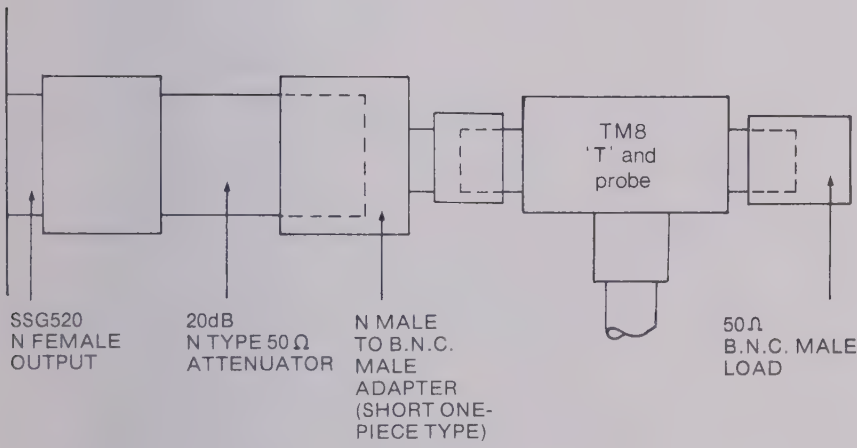


Fig 1

EXTERNAL RANGE PROGRAMMING

Range selection may be performed externally by selecting the 'EXT' facility on the front panel and then using the programming socket on the rear panel. N.B. Programming is TTL compatible, sink to operate (i.e. connect to 0V).

Range code

RANGE NUMBER	RANGE SETTING FSD	PROGRAMME SOCKET		
		PIN 1 A	PIN 2 B	PIN 3 C
0	3V	1	1	1
1	1V	0	1	1
2	300mV	1	0	1
3	100mV	0	0	1
4	30mV	1	1	0
5	10mV	0	1	0
6	3mV	1	0	0
7	1mV	0	0	0

1 = +5V, 0 = 0V

A d.c. analogue output is available from the programme socket where FSD is equivalent to 1V from a low impedance buffer

Programme socket connections

PIN NUMBER	FUNCTION
1	BCD range select (TTL) A
2	BCD range select (TTL) B
3	BCD range select (TTL) C
4	
5	BCD range data outputs (CMOS) A
6	BCD range data outputs (CMOS) B
7	BCD range data outputs (CMOS) C
8	Meter reading hold
9	Meter reading analogue output
10	EXT confirm (+ 5V is EXT)
11	0V
12	External d.c. input + 15V to + 30V
13	External d.c. input -15V to -30V
14	

CIRCUIT DESCRIPTION

Sampling probe

The r.f. signal to be measured is converted to an I.F. signal of proportional amplitude by utilising a random sampling technique. The Schottky diodes, D1 to D4, act as very fast switches in a sampling gate. When the diodes are conducting the instantaneous r.f. input voltage is stored on the gate of VT1. The sampling bridge diodes are normally reverse biased and are rapidly forward biased by complementary positive and negative sampling pulses of approximately 300ps duration. In order to give a continuous I.F. output over a wide range of r.f. input frequencies, the sampling pulse repetition rate is swept from 10kHz to 20kHz at a 5Hz rate. The I.F. output is then taken from the drain of the probe F.E.T., VT1,to the I.F. amplifier input on the main circuit board.

Pulse generator

The timing circuit, IC3, generates an approximately triangular sweep waveform which is amplified by IC4. The potential divider, P2, R12, provides an adjustable d.c. offset for the sweep waveform. This sweep voltage tunes the astable multivibrator, VT1, 2 and C13, 14. The V.C.O. operates from 10kHz to 20kHz and is swept at a 5Hz rate. The output of the V.C.O. is squared by VT3 which also provides an output to drive the synchronous sampler on the main circuit board.

The output of VT4 is differentiated by C17, R23 to produce pulses of approximately 1μs duration. Transistor VT5 provides the drive for the Darlington amplifier VT6, 7. Step recovery diodes D12, 13 are normally forward biased and are rapidly reverse biased by the pulses from the collector of VT7.

This rapid reverse biasing produces very fast sampling pulses. The pulse transformer, TX2, is used to derive a complementary pulse to drive the probe sampling bridge. The bridge bias and balance controls, P5 and P4, provide adjustable reverse bias voltages for the sampling bridge. The balance control allows slight variations in the pulse amplitude to be corr-ected, while the bias control allows adjustment of the 'on' time of the sampling bridge and some control of the r.f. frequency response.

Main circuit board

The I.F. output from the sampling probe is fed to the I.F. attenuator circuit board which is mounted in a screened box on the main circuit board. This protects the amplifier from spurious noise signal inputs.
IC3 forms a high gain amplifier preceded by an attenuator for each of the TM8's eight ranges. The attenuators are switched in by the analogue gates of IC1, IC2 and the adjustment of P1 to P8 allows each range FSD to be calibrated. The attenuator I.F. output at pin 53 is approximately 600mV pk-pk for FSD on each range.

On the lower ranges of the TM8 a significant proportion of the noise on the I.F. signal is coherent with the sampling pulse repetition rate (10kHz to 20kHz). To improve the signal to noise ratio of the I.F. signal, a synch-ronous sampler technique is employed. To remove the noise, the I.F. signal is passed through a dual sample and hold circuit comprising the analogue switches of IC4 and holding capacitors C5, C6. The analogue switches are driven by two complementary 5kHz to 10kHz switching waveforms derived by IC5 from the 10kHz to 20kHz sampler pulse drive. Using this technique, any noise coherent with the sampling pulse repetition rate is removed by the synchronous sampler. IC6 amplifies the I.F. signal to approximately 5V pk-pk at T.P.1 for F.S.D.

The I.F. signal is then detected simultaneously by the true r.m.s. circuit, IC8, and the average detector, comprising ½ IC9. IC8 also has a log scale output which when amplified by ½ IC9, provides a useful 4 decade single range log scale. This scale is selected by the front panel range switch.

The detected outputs are routed, via the front panel 'r.m.s./average' switch, to the d.c. amplifier, IC14. A small offset voltage from P12 (1mV zero) is added to IC14 to cancel the 1mV range residual noise. IC14 also serves as a holding amplifier for the reading hold facility. The probe hold switch pulls the gate voltage at pin 6, IC13 to 0V, thus opening the analogue switch and storing the last reading on the holding capacitor, C17.

The output of IC14 is fed to IC17 which adds a small linearity correction to cancel out the effects of zero offsets. C25 provides meter damping and is switched in or out of circuit by the front panel 'Fast/Slow' switch.

In the autoranging mode, the d.c. output of IC14 is monitored by the level detect circuitry comprising IC15, 16. When the meter drive voltage exceeds the reference voltage at pin 3, IC15, the change-up multivibrator is enabled. Similarly, when the meter drive voltage falls below the reference voltage at Pin 2, IC16 the change-down multivibrator is enabled. The B.C.D. counter, IC10, is thus clocked up or down at a rate of approximately 4Hz.

The B.C.D. code of IC10 is decoded by IC7 into eight separate ranges which are steered, via diodes D4-D11, to the corresponding eight range select lines. The range upon which the TM8 is set is thus clocked up or down automatically until the meter drive voltage is within the window of the reference chain voltages. These reference voltages are equivalent to approximately FSD + 5% for overrange and 20% of FSD for underrange.

The autoranging circuitry is only enabled when the TM8 is switched to 'AUTO'. In the 'EXT' mode, the B.C.D. counter is inhibited and the output code of IC10 is set by the counter programme inputs. Transistors VT4, 5, 6 are level translators so the ext. range select lines are TTL compatible.

Block diagram

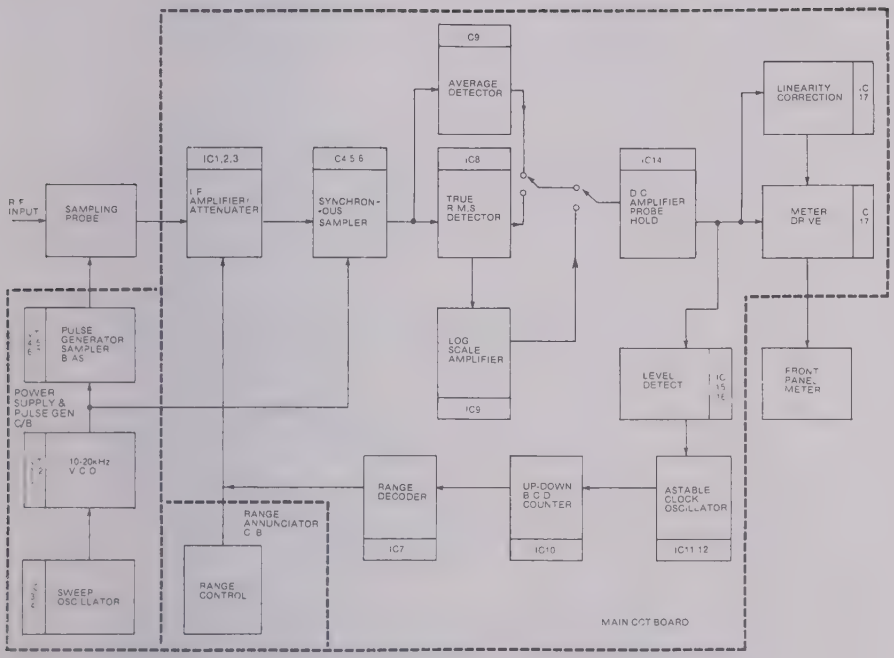


Fig 2

TEST AND CALIBRATION PROCEDURE

1. Power supply

a) Fit the mains fuse (150mA A/S) and check the input is set to 240V (back panel voltage setting switch).

b) Supply mains to the unit via a variac and ammeter. At 240V input the mains current should be approximately 15mA. Check the voltage across C1 is 28V ± 2V and C2 is 30V ± 2V. Check the ± 12V rails (C6, C7) are within + 10%, -5%.

c) Ensure the ± 12V rails are maintained within the above limits for mains input of 180V to 260V.

d) Set voltage setting switch to 115V and check ± 12V rails are within limits in c) over the mains input range of 85V to 135V.

2. Pulse generator

a) Connect a power supply between TP2 (+ ve) and earth (-ve). Monitor with a scope TP3 and ensure the presence of the V.C.O. output over the tuning range of approximately 1.5V to 15V. Set the tuning volts to 3.0V and check the V.C.O. frequency is 10kHz. If the frequency is too high select a resistor between P.S.U. + ve and TP2 until correct. Check the tuning volts required to give 20kHz is 8V to 9V. Fit the S.O.T. for TP2 and link TP1.

b) Monitor with a scope TP2 (nearest the front panel) and set the sweep waveform to start at 3V with P2. Adjust P1 for a sweep frequency of 5Hz. Fit S.O.T. resistor in TP1 position if 5Hz cannot be set (S.O.T. typically 1MΩ). Adjust P3 (pin 24) for a step recovery diode bias of 10.0V.

c) Check the probe diode bias pins (feedthroughs on pulse generator box) for correct operation of the bridge bias and balance pots P5, P4. Set P4, P5 to mid range.

d) Check pin 29 for a probe FET source bias of -2.0V and Pin 41 (on the I.F. amplifier C/B) for a drain bias of 7V ± 1V.

e) Monitor the probe tip output on a scope (50MHz or greater bandwidth). Adjust P4 for minimum sampling pulse noise.

3. Main circuit board

a) Select 'autoranging' and check the + ve end of C30 for 4.7V ± 0.3V. Check IC5 pin 14 for + 8V ± 0.5V and pin 7 for -8V ± 0.5V.

b) Temporarily fit a 220Ω resistor in R57 position.

c) On the 1mV range, with no input, the I.F. output (pin 53) must be <5V pk-pk.

4. Frequency response

a) Connect the equipment of Fig. 3 (page 13). Set the generator to 100MHz and level to -8dBm on the power meter. Select the 100mV range on the TM8 with r.m.s. mode. Adjust P5 (on the I.F. Amplifier C/B) for a meter reading of 90% FSD.

b) Reset the generator to 1000MHz, -8dBm, and adjust the sampling bridge bias control (P5 on the pulse generator C/B) for 90% FSD. Repeat until the 100MHz and 1000MHz readings are correct.

c) Check the frequency response

100kHz to 200MHz	± 2%
20kHz to 500MHz	± 5%
10kHz to 1GHz	± 11%

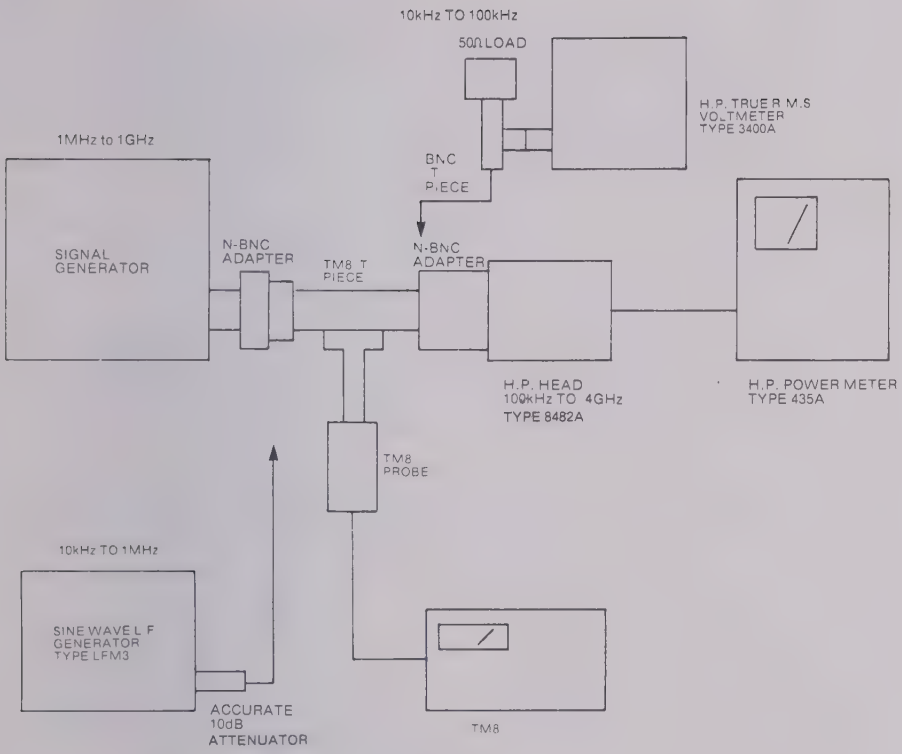


Fig 3

5. Range calibration

a) Assemble the equipment of Fig. 4 (Page 14). Set the signal generator to 100MHz and adjust the output level so the power meter reads + 3dBm. Set the TM8 to the 300mV range and adjust P6 (on the I.F. Amplifier C/B) for FSD. Using the signal generator r.f. attenuator, reduce the input level by 10dBm and adjust P16 for 1/3 FSD. Remove the r.f. input and adjust P14 for zero reading. Repeat FSD, 1/3 FSD and zero adjustments until correct.

b) Select TM8 1mV range and set the signal generator to 1mV output (using the 10dB step attenuator). Adjust P1 for FSD, P15 for 1/3 FSD and P12 for zero on the TM8 meter. Repeat until correct.

c) Select the 3mV range. Adjust P2 for FSD. Check 1/3 FSD and S.O.T. R88 for zero (R88 typ. 2M7). Calibrate the 10mV to 3 V ranges, adjusting P3 to P8 for FSD. Check 1/3 FSD, and 2/3 FSD. If necessary 1/3 FSD on the 3V range may be increased by fitting a S.O.T. resistor in R113 position (on the I.F. Amplifier C/B) and resetting FSD.

d) Set FSD on the 300mV range and select average response. Adjust P11 for FSD. Select the 1mV range, 'r.m.s.' mode. Check the zero reading when switching to 'average' mode. S.O.T. 57 to correct.

e) Set FSD on the 30mV range. Select auto ranging and adjust P13 for a range change up at FSD + 5%. Check the correct operation of the auto-ranger on all ranges.

f) Select the 'log' range and set P10 fully c.c.w. Set P9 to calibrate 0dBm and P10 for -30dBm input. Repeat until correct. Check the accuracy of the 10dB steps is within 2dB.

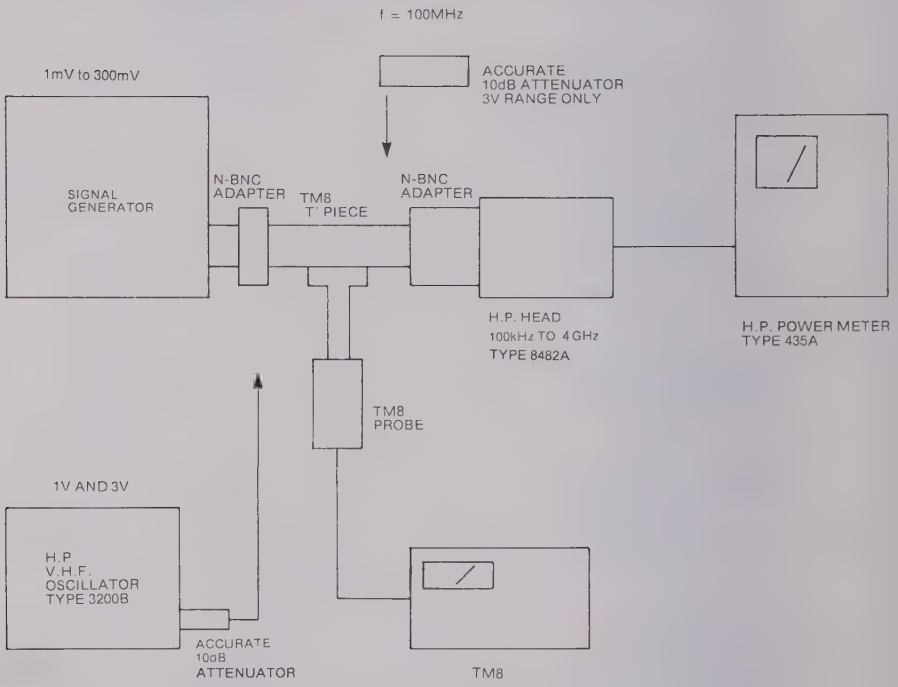


Fig 4

6. Additional checks

a) Soak the TM8 for 8 hours at 40°C. Recheck the frequency response and calibration.

b) Calibrate the X100 probe on the 10mV range with 1V input, at 100MHz Check the additional frequency response error is within ± 6% 1MHz to 500MHz.

c) Select 'EXT' and check all programmable functions.

MAINTENANCE

Guarantee

The equipment supplied by Farnell Instruments Ltd., is guaranteed against defective material and faulty manufacture for a period of twelve months from the date of despatch. In the case of material or components employed in the equipment but not manufactured by us, we allow the customer the period of any guarantee extended to us.

The equipment has been carefully inspected and submitted to comprehensive tests at the factory prior to despatch. If, within the guarantee period, any defect is discovered in the equipment in respect of material or workmanship and reasonably within our control, we undertake to make good the defect at our own expense subject to our standard conditions of sale. In exceptional circumstances and at the discretion of the Service Manager, a charge for labour and carriage costs incurred may be made.

Our responsibility is in all cases limited to the cost of making good the defect in the equipment itself. The guarantee does not extend to third parties, nor does it apply to defects caused by abnormal conditions of working, accident, misuse, neglect or wear and tear.

Maintenance

In the event of difficulty, or apparent circuit malfunction, it is advisable to telephone (or telex) the Service Department or your local Sales Engineer or Agent (if overseas) for advice before attempting repairs.

For repairs it is recommended that the complete unit be returned to:-

The Service Department,
Farnell Instruments Ltd.,
Sandbeck Way,
Wetherby,
West Yorkshire.
LS22 4DH
Tel: 0937 61961 Telex: 557294

or

The Service Department,
Farnell Instruments Ltd.,
Davenport House,
Bowers Way,
Harpenden, Herts.
AL5 4HX
Tel: 05827 69071 Telex 826307

Please ensure adequate care is taken with packing and arrange insurance cover against transit damage or loss.

COMPONENT LISTS

MAIN BOARD 5N0872008 (Circuit diagram 1ZX08722200)

Circuit ref.	Component	Description	Farnell Item No.
R61,84,120	Resistor	1K0R 2% MR25	RM41K0025
R53,74	Resistor	2K2R 2% MR25	RM42K2025
R63,82	Resistor	2K7R 2% MR25	RM42K7025
R49,94,106	Resistor	3K3R 2% MR25	RM43K3025
R37,83	Resistor	4K7R 2% MR25	RM44K7025
R105,115,117,119	Resistor	5K6R 2% MR25	RM45K6025
R71	Resistor	10KR 2% MR25	RM510K025
R30,48,59,81,114,116,118	Resistor	12KR 2% MR25	RM512K025
R44,45,85,86	Resistor	15KR 2% MR25	RM515K025
R36,46,69,72,99,102	Resistor	18KR 2% MR25	RM518K025
R25-29,32-34,39,52,67,68,87,112	Resistor	22KR 2% MR25	RM522K025
R77-79,95	Resistor	27KR 2% MR25	RM527K025
R73,90,122-125	Resistor	33KR 2% MR25	RM533K025
R35,75,100	Resistor	39KR 2% MR25	RM539K025
R50,54,58,111	Resistor	56KR 2% MR25	RM556K025
R56,97	Resistor	82KR 2% MR25	RM582K025
R31,43,51,70	Resistor	100KR 2% MR25	RM6100K25
R47,76	Resistor	120KR 2% MR25	RM6120K25
R55,103	Resistor	180KR 2% MR25	RM6180K25
R91	Resistor	560KR 2% MR25	RM6560K25
R80,89,110	Resistor	1M0R 5% CR25	RC71M0025
R65,66	Resistor	2M2R 10% CR25	RC72M2025
R38,41	Resistor	330R 2% MR25	RM3330R25
R96	Resistor	2K4R 2% MR25	RM42K4025
R92,104	Resistor	270KR 2% TR4	RX6270KT4
R57,88	Resistor	Select on test	-
R121	Resistor	820R 2% MR25	RM3820R25
R126	Resistor	1K5R 2% MR25	RM41K5025
C20,21	Capacitor	120pF 861/N470	CC3120P861
C11	Capacitor	1K0pF 861/AX	CC41K00861
C4,18,19	Capacitor	10kpF 861T/25	CC510K0861
C9,16,29,31	Capacitor	10µF 25V 015	CE210U0GM
C22,28	Capacitor	22µF 10V 015	CE222JCDM
C23	Capacitor	33µF 16V 015	CE233J0FM
C7,8,30	Capacitor	47µF 10V 015	CE247U0DM
C25	Capacitor	220µF 16V 016	CE322OJFM
C12-15	Capacitor	0.1µF 100V MKS3	CF0U10ONMKS3
C17	Capacitor	1µF 63V A2B	CF11U0GLA2B
C5	Capacitor	10KpF 100V FKS2M1N	CF510K0N2M1N
C10	Capacitor	1µF 35V TAG1/35 ITT	CT11U0016
C27	Capacitor	0.1µF 250V B32511	CF0U10OR325
C6	Capacitor	1K0pF 100V FKS2	CF41K00NFKS2
C24	Capacitor	1µF 100V 344	CF11U0GN344
C26	Capacitor	0.47µF 100V 344-25474	CF0U47ON344
D1-17,19,20	Diode	1N4148	DG4148
Z1,4	Zener	ZPD4.7	DZZF47P
Z2,3	Zener	ZPD8.2	DZZF82P
P13	Potentiometer	5K0R 63P	PM45K0063P
P11	Potentiometer	50KR 63P	PM550K063P
P9,10,15	Potentiometer	100KR 63P	PM6100K63P
P12,14	Potentiometer	50KR 43P T040	PM550K43P
P16	Potentiometer	1M0R 63P	PM71M0063P
P17	Potentiometer	200R 63P	PM3200R63P

Circuit ref.	Component	Description	Farnell Item No.
IC15,16	Integrated circuit	CA3130E	VA3130E
IC6	Integrated circuit	UAF356TC	VA356TC
IC12	Integrated circuit	CD4002BE	VD4002BE
IC5	Integrated circuit	CD4013BE	VC4013BE
IC4,13,18	Integrated circuit	CD4016BE	VD40168
IC10	Integrated circuit	CD40192BE	VD40192B
IC11	Integrated circuit	CD4069BCN	VD4069BCN
IC8	Integrated circuit	AD536AJD	VA536AJ
IC7	Integrated circuit	CD4028B	VD4028B
IC9,17	Integrated circuit	MC1458NP	VA1458NP1
IC14	Integrated circuit	CA3240AE	VA3240E
VT1-6	Transistor	BC182PL	VT182PL
Miscellaneous items			
SW1, SW2	Front panel slider switches		SS0103
M1	Meter		EM0872300
Printed circuit board without components			BC0872100

I.F. ATTENUATOR 4N0872007 (Circuit diagram 1ZX0872200)

Circuit ref.	Component	Description	Farnell Item No.
R20,24	Resistor	390kR 5% CR25	RC6390K25
R4	Resistor	560kR 5% CR25	RC6560K25
R17	Resistor	680kR 5% CR25	RC6680K25
R16,18	Resistor	100R 2% MR25	RM3100R25
R14	Resistor	180R 2% MR25	RM3180R25
R12	Resistor	470R 2% MR25	RM3470R25
R1	Resistor	560R 2% MR25	RM3560R25
R10	Resistor	1k8R 2% MR25	RM41K802S
R8	Resistor	8k2R 2% MR25	RM48K202S
R19,21,22,23	Resistor	12kR 2% MR25	RM512K02S
R6	Resistor	27kR 2% MR25	RM527K02S
R11	Resistor	100kR 2% MR25	RM6100K25
R3,5,9,13	Resistor	120kR 2% MR25	RM6120K25
R7	Resistor	180kR 2% MR25	RM6180K25
R2	Resistor	330R 2% MR25	RM3330R25
R101	Thermistor	390R 10% TG1/8	RT3390RTG18
R109	Resistor	39kR 2% MR25	RM539K02S
R15	Resistor	220kR 2% MR25	RM6220K25
R113	Resistor	Select on test	-
C3	Capacitor	0.1µF 100V MKS3	CF0U100NMKS3
C1	Capacitor	4.7µF 25V TAG4.7/25	CT14U70GG
X13	Feed thru capacitor	1kOP	CD41K00N54
P7,8	Potentiometer	100R 63P	PM3100R63P
P6	Potentiometer	200R 63P	PM3200R63P
P5	Potentiometer	500R 63P	PM3500R63P
P4	Potentiometer	20kR 63P	PM42K0063P
P3	Potentiometer	10kR 63P	PM510K063P
P2	Potentiometer	25kR 63P	PM525K063P
P1	Potentiometer	1MOR 63P	PM71M0063P

D21	Diode	1N4148	DG4148
IC1,2	Integrated circuit	CD4016BE	VD4016B
IC3	Integrated circuit	MC1458NP1	VA1458NP1

Miscellaneous items

Printed circuit board without components	BC0872104

POWER SUPPLY AND PULSE GENERATOR 5N0872011 (Circuit diagram 2ZX0872202)

Circuit reference	Component	Description	Farnell Item No.
R27	Resistor	100R 2% MR25	RM3100R25
R14,17,22	Resistor	1k2R 2% MR25	RM41K2025
R20,23	Resistor	1k5R 2% MR25	RM41K5025
R3,24	Resistor	2k2R 2% MR25	RM42K2025
R12,33-35	Resistor	2k7R 2% MR25	RM42K7025
R2	Resistor	4k7R 2% MR25	RM44K7025
R37	Resistor	5k6R 2% MR25	RM45K6025
R1,38	Resistor	6k8R 2% MR25	RM46K8025
R11	Resistor	8k2R 2% MR25	RM48K2025
R4,7,13,18,19	Resistor	10kR 2% MR25	RM510K025
R15,16	Resistor	12kR 2% MR25	RM512K025
R36	Resistor	15kR 2% MR25	RM515K025
R10,21	Resistor	27kR 2% MR25	RM527K025
R9	Resistor	33kR 2% MR25	RM533K025
R8	Resistor	39kR 2% MR25	RM539K025
R5	Resistor	560kR 5% CR25	RC6560K25
R40	Resistor	18R 2% MR25	RM218R025
R39	Resistor	Select on test	-
C15	Capacitor	47pF 801/N470	CC247P0801
C17,20	Capacitor	1k0pF 861/AX	CC41K00861
C11,16,19,28,29	Capacitor	10kpF 861T/25	CC510K0861
C10,18,22,25-27	Capacitor	33µF 16V 015	CE233U0FM
C6,7	Capacitor	220µF 16V 016	CE3220UFM
C2	Capacitor	680µF 40V 032-17681	CE3680UJM
C1	Capacitor	1k0µF 35V PRNT	CE41K00IW
C12	Capacitor	0.1µF 100V MKS3	CF0U100NMKS3
C3,4,8,9	Capacitor	0.1µF 250V B32511	CF0U100R325
C13,14	Capacitor	2k2pF 100V FKS2MIN	CF42K20NFKS2
P3	Potentiometer	500R 63P	PM3500R63P
P5	Potentiometer	10kR 63P	PM510K063P
P2	Potentiometer	25kR 63P	PM525K063P
P4	Potentiometer	100kR 63P	PM6100K63P
P1	Potentiometer	1M0R 63P	PM71M0063P
D1-6	Diode	1N4003	DG4003
D7-11	Diode	1N4148	DG4148
IC4	Integrated circuit	CA741CG	VA741CG
IC3	Integrated circuit	ICM7555IPA	VA7555IPA
IC1	Integrated circuit	UA78MGUIC	VA78MGUIC
IC2	Integrated circuit	UA79MGUIC	VA79MGUIC
VT1-3	Transistor	BC182PL	VT182PL
VT4,6	Transistor	ZTX313	VTX313
VT5	Transistor	ZTX510	VTX510
VT7	Transistor	2N3866A	VT3866A

SW1	Power switch	KPG206N	SB206N
SW2	Voltage selector switch	46206LFE	SS46206
TX1	Transformer	207-813 (power)	ZR207813
F1	Fuse holder	FH333	FH520TP
F1	Fuse (power)	TDC123	FT160M123
Printed circuit board without components			BC0872112

PULSE GENERATOR BOX 4N0872006 (Circuit diagram 2ZX0872202)

Circuit ref.	Component	Description	Farnell Item No.
R40	Resistor	18R 2% MR25	RM218RC25
R29,30	Resistor	82R 2% MR25	RM282RC25
R25	Resistor	100R 2% MR25	RM3100R25
R26	Resistor	1K0R 2% MR25	RM41K0025
R28	Resistor	1K2R 2% MR25	RM41K2025
R31,32	Resistor	5K6R 2% MR25	RM45K6025
C21,23,24	Capacitor	1K0pF 861	CC41K00861
C30	Capacitor	33pF 801/N470	CC233P0801
-	Capacitor	1K0pF feedthrough	CC41KC0N54
D12,13	Diode	5082-0180	DG0180
VT7	Transistor	2N3866A	VT3866A
VT6	Transistor	ZTX313	VT313

Miscellaneous items

Transistor clip A1061	HR1051
Ferrite bead FX1115	ZF1115
Feedthrough FTSM 16P51	TM16P51

RANGE ANNUNCIATION C.B. 5NO872010 (Circuit diagram 3ZX0872201)

Circuit reference	Component	Description	Farnell Item No.
R2,4,6,8,10,12,14,16,19,22,24	Resistor	1K2R 2% MR25	RM41K2025
R1,3,5,7,9,11,13,15,18,21,23	Resistor	18KR 2% MR25	RM518K025
R17,20	Resistor	22KR 2% MR25	RM522K025
D1	Diode	1N4148	DG4148
VT1-11	Transistor	BC182PL	VT182PL
LED1-11	LEDs	5082-4650 HP red	LD4650
SW1	Switch	Rotary	SW0872302
Miscellaneous items			
Printed circuit board without components			BC0872108

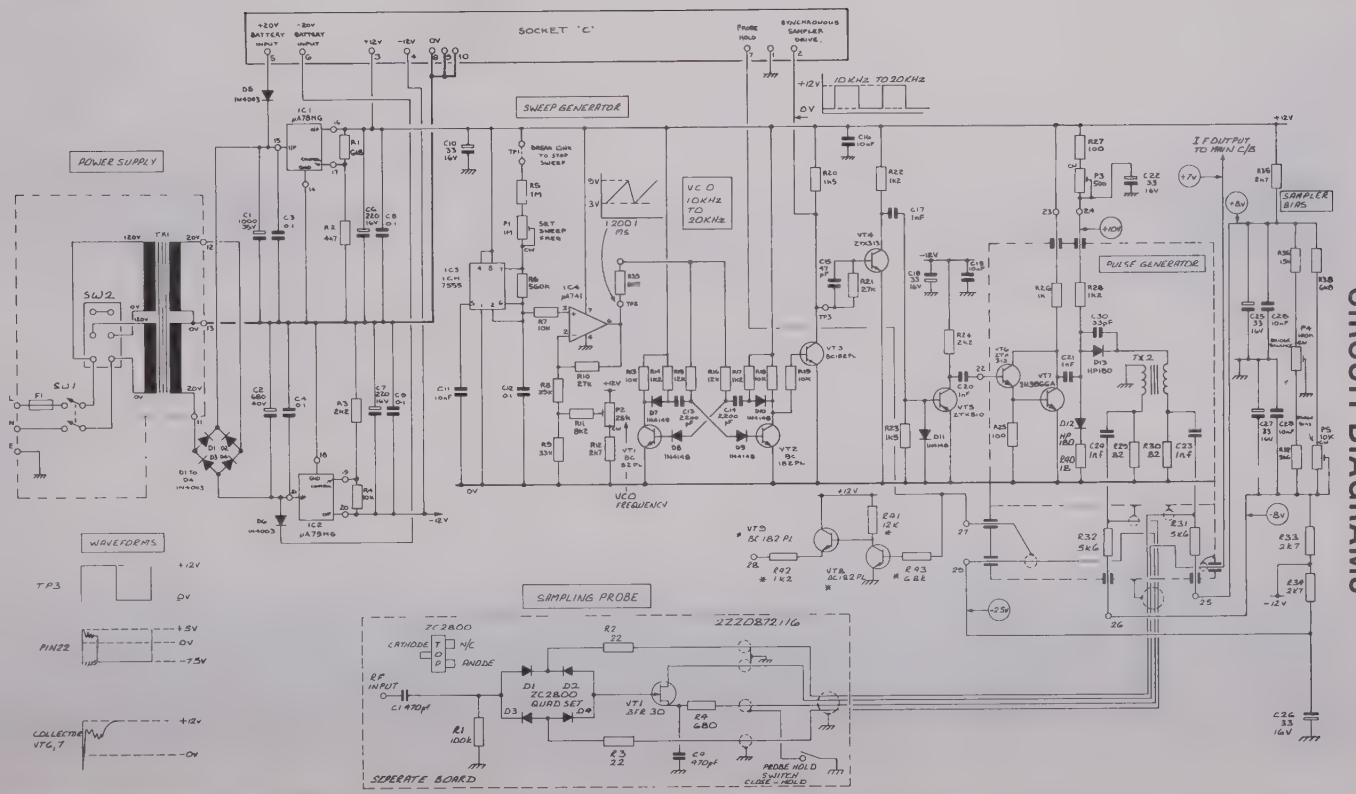
SAMPLING PROBE (Circuit diagram 2ZX08722202)

Circuit ref.	Component	Description	Farnell Item No.
R1	Resistor	100kR 5% CR16	RC6100K16
R2,3	Resistor	22R 5% CR16	RC222R016
R4	Resistor	680R 5% CR16	RC3680R16
C1,4	Capacitor	470pF 201R16W471KP Chip	CC3470PQ16
C2	Capacitor	24 s.w.g. wire link	CLINK24
D1-4	Diode	Matched set ZC2800E	DG2800E
VT1	Transistor	BFR30	VTR30
Miscellaneous items			
Probe main body			HW0872520
Probe rear body			HW0872521
Probe sleeve			HW0872522
Spring contact			HW0872523
Probe button			HW0872524
Probe tip			HW1026
Probe bush			HW1027
Probe cable			YX59083
M3 grub screw			KS3M3
Printed circuit board without components			BC0872116

HARDWARE

Back panel	Farnell Item No.
Fuse shroud Bulgin 9820	FS9820
14 way socket 14W 57/40140	TG40140
14 way plug 14W 57/30140	TG30140
Power socket PS620/3	TK6203
Power lead 22/V/2	HC22V2
Fuse holder FH333	FH520TP
Front panel	
Black knob Sifam S210250	HK210250
Black knob cap C210	HK210
Red knob S100125	HK100125R
Red knob cap C100	HK100R
Plastic front panel	HW0872501
Chassis	
Handle	HA0457
Handle retainer	HM0026
Earth tag	TS0486
Side trim	7SX0609
LHS trim	7NX0872511
T/B trim	7SX0603
Push rod	HW0872512
Bottom cover	7SU0740
Top cover	7SU1118
Folding foot	HF0001
Plastic feet	HM0027
End mouldings	HM0025
Moulding clamps	HR0484
Accessories	
Zip wallet	JP1117
Divide by 100 probe	4N0872107
Probe to 'T'	4N0872016
Probe to BNC	4N0872015
Earth link	FH499
Croc clip	TM423807
Spare prob tip	HW1026

CIRCUIT DIAGRAMS



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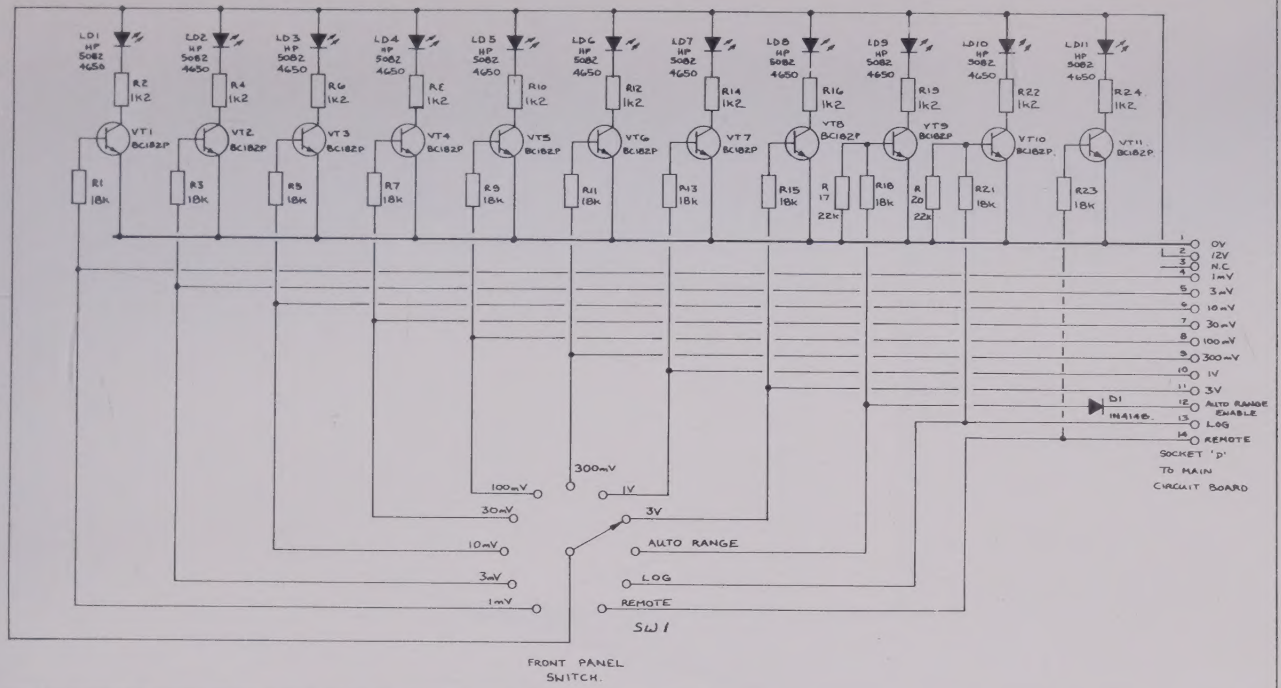

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